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# A COMPARATIVE ANALYSIS OF FIVE MEDICINAL FLORAS

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ABSTRACT.– We report a striking similarity in the selection of medicinal plants by widely separated non-western peoples. People across the northern hemisphere (in Chiapas, North America, Korea and Kashmir) have selected similar plant species — members of the same plant families — for medicinal use; the sunflower family (Asteraceae), for example, ranks first in 3 of 4 regions and second in the fourth. Only 9 plant families are needed to delineate the 5 most important medicinal plant families in these 4 regions. Likewise, there is striking similarity in the plants neglected for use as medicine: the grass family (Poaceae) ranks last in 3 of 4 regions and second in the fourth. These patterns may be due to the relatedness of the northern floras and to the cultural transmission of knowledge through time and space; they may demonstrate the existence of a global pattern of human knowledge.

Key words: plant selection, medicinal floras, regression analysis

RESUMEN.– En este trabajo se reporta que en poblaciones no occidentales claramente separadas unas de otras, existe una similitud asombrosa en cuanto a la selecció6n de plantas medicinales. En Chiapas, América del Norte, Corea y Kashimir, cuatro regiones del hemisferio norte, la gente ha seleccionado especies parecidas – esto es, representantes de las mismas familias de plantas – para usos medicinales. Por ejemplo, la familia de los girasoles (Asteraceae) ocupa el primer lugar en tres de estas cuatro regiones y el segundo en la otra. Por otro lado, se necesitan sóólo nueve familias para clasificar a las cinco familias máás importantes en estos lugares. Ademáás, tambiéén existe similitud entre las plantas desechadas para este mismo uso, la familia de los pastos (Poaceae) ocupa el úúltimo lugar en tres de las regiones y el segundo en la cuarta. Esto puede deberse tanto al tipo de flora existente en el hemisferio norte como a la transmisióón cultural de conocimientos a travéés del tiempo y del espacio, esbozando la existencia de un patróón global de conocimiento humano.

RÉSUMÉ.– Cet article expose une ressemblance frappante entre les selections de plantes médicinales par des peuples non-occidentaux largement dispersés. Les populations de quatre régions de l'hémisphère Nord (Chiapas, Amérique du Nord, Corée, et Kashmir) ont sélectionné des espèces botaniques similaires—c'est-à-dire appartenant aux même familles botaniques—pour leur emploi médicinal. Par exemple, parmi toutes familles sélectionnées, la famille des tournesols (Asteraceae) s'emploie le plus fréquemment dans 3 des 4 régions, et est en deuxième place dans la 4e région. En fait il ne faut que 9 familles botanique pour définir les 5 plantes medicinales les plus importantes dans ces 4 regions. De même il y a une ressemblance frappante entre les plantes qui n'ont pas été choisies pour leur vertu pour l'emploi médicinale. La familles des herbes (Poaceae) est classée la dernière dans 3 des 4 régions, et avant derniere dans la 4e région. Ces motifs pourraient s'expliquer par la parenté entre les flores nordiques et par la transmission culturelle des savoirs à travers le temps et l'espace; il se peut qu'elles démontrent l'existence d'un motif global des savoirs humains.

## INTRODUCTION

Identification of the plant species used as medicine by many individual cultures has long been an active area of research (Berlin and Berlin 1996; Johns 1990; Moerman 1998). A few studies have sought to relate the medical plant species selected to the floras to which the plants belong in order to understand what kinds of plants are more or less important (Moerman 1991; Moerman 1996; Phillips and Gentry 1993). However, almost nothing is known about possible patterns of medicinal plant selection by human beings across cultures, regions, and hemispheres. In this paper, we report research showing significant similarities (and some differences) in patterns of selection and avoidance of plants for medicine for 5 well-separated peoples and floras.

In 1992, Moerman, in collaboration with others, compared the medicinal flora of the Majouri-Kirchi forests of Jammu and Kashmir State, in India, with the medicinal flora of the native peoples of North America (Kapur et al. 1992). Utilizing data from that paper and new data from 3 other regions — from Korea, the Chiapas Highlands of Mexico, and Eastern Ecuador — we extend that comparison.

## METHODOLOGY

The comparison utilizes the regression and residual analysis developed by Moerman (Moerman 1991) wherein one carries out a regression analysis of the number of medicinal species per family on the total number of species in each family; a regression analysis for the data from North America is displayed and explained in Figure 1. Lacking any particular selectivity, such an analysis would show that large families had large numbers of medicinal species and that small ones did not. In previous publications, it has been shown that some families were used much more often than simple chance would allow, and others were used less often (Moerman 1991; Moerman 1996). In particular, in such an analysis, families can be ranked by the size of their "residuals." The residual is the difference between the regression analysis prediction of number of medicinal species and the actual, ethnographically determined, number of medicinal species. Large, positive residuals indicate families favored for use as medicines while large, negative residuals indicate families generally ignored. Ranking families by residual allows us to compare the medicinal floras of peoples separated in space and time.

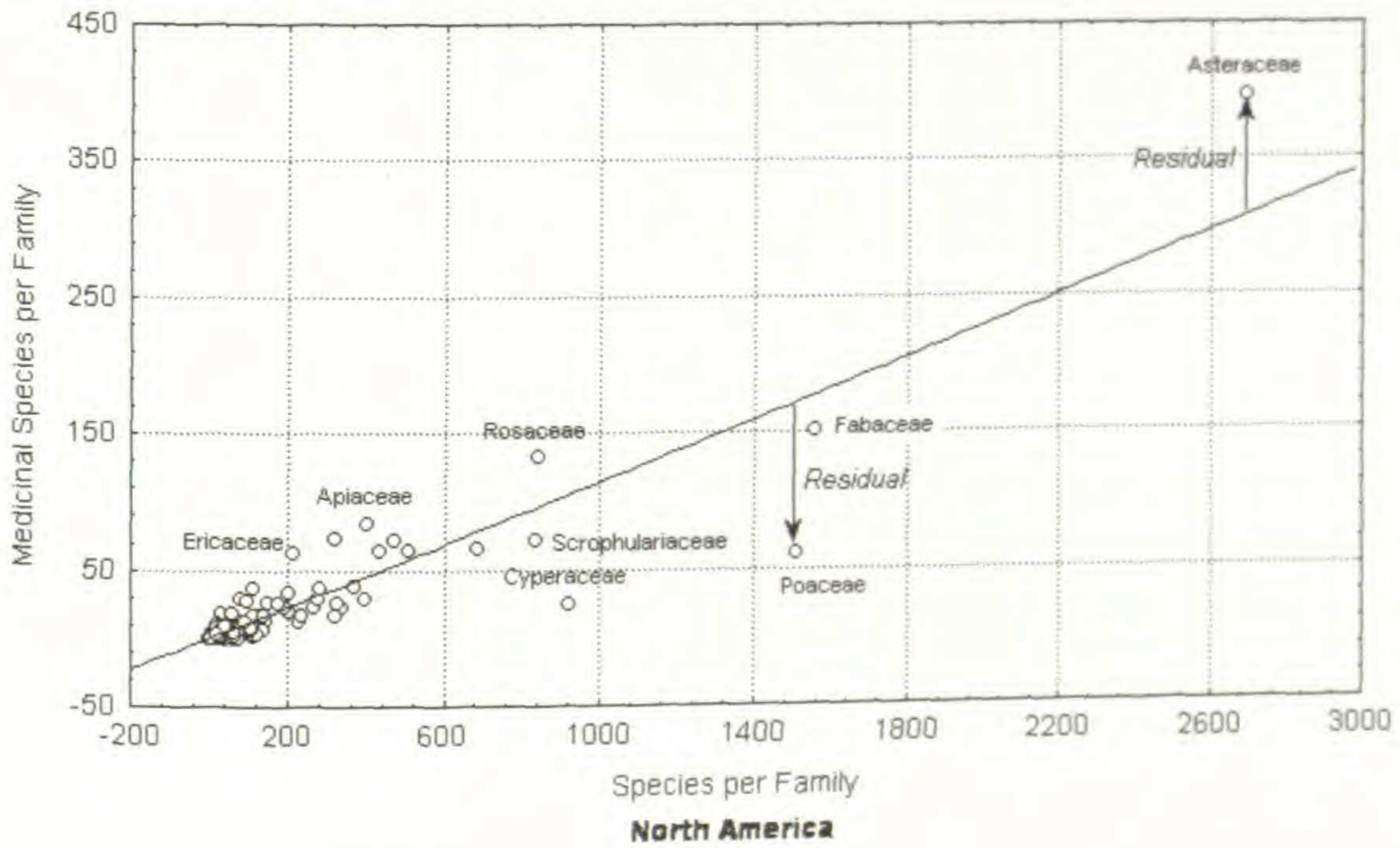


FIGURE 1.– Regression plot for North America.

In this graph, each point represents two values for a plant family, the total number of species in North America (north of the Rio Grande) along the horizontal axis (TSp), and the number of species in each angiosperm family used medicinally by native American peoples along the vertical axis (MSp). The graph line from lower left to upper right is the line represented by the regression equation, calculated from a standard least-squares regression (Runyon and Haber 1984). [2]

Another way to determine the relationships between these different medicinal floras is to calculate the Pearson correlation coefficients (Runyon and Haber 1984:140-155) between the residuals from the five regions, taking two regions at a time as shown in Figure 2.

*The Regression Analysis*.– Appendix 1 gives all the numerical data considered in this paper. Table 1 summarizes the results of the 5 least-squares regression analyses (Runyon and Haber 1984:164-183). In each case in the table, the predicted value (Pv) for the number of medicinal species in a particular family which has N species is determined by the equation:

$$Pv = Constant + (N * Coefficient)$$

The residual (R) is the actual number of medicinal species in that family (Av) less the predicted value (Pv):

$$R = Av - Pv$$

Calculating this figure for each family for each of the 5 regions allows us to rank the families in terms of decreasing residuals. Families with large positive residuals — with more species used medicinally than the size of the family would predict — are at the top of such a list, while families with large negative residuals — with fewer species used medicinally than the size of the family would predict — are at the bottom of the list. We number the families in each area from 1 to n — where n is the number of families in the region — from top to bottom, and from bottom to top. The top 5 families and the bottom 5 families of each region are indicated in tables 2 and 3.

TABLE 1.– Basic data and equation parameters for regressions of number of medicinal species on total number of species per family for 5 regions. "Coefficient" and "Constant" are described in the text, and in the caption to Figure 1.

| | Families (angiosperms) | Species | Medicinal Species | Coefficient | Constant |
|---|---|---|---|---|---|
| North America | 225 | 20,669 | 2,428 | .114 | .284 |
| Korea | 136 | 2,506 | 591 | .155 | 1.49 |
| Kashmir | 100 | 739 | 466 | .541 | .662 |
| Ecuador | 118 | 1,729 | 133 | .054 | .342 |
| Chiapas Highlands | 144 | 6,606 | 1,639 | .230 | .829 |

## DATA

The analysis presented here rests on 5 different sets of data, in each case a listing of all the families of angiosperms found in the particular region, with counts of the total number of species in each family, and the number of those species utilized as medicines by native peoples in the regions. While there are many interesting medicinal gymnosperms, data for them were not available for all the regions, so this analysis is only of angiosperms.

As taxonomists do not necessarily agree on the family-level classifications of the world's plants, we have had to adopt some simplifying conventions in order

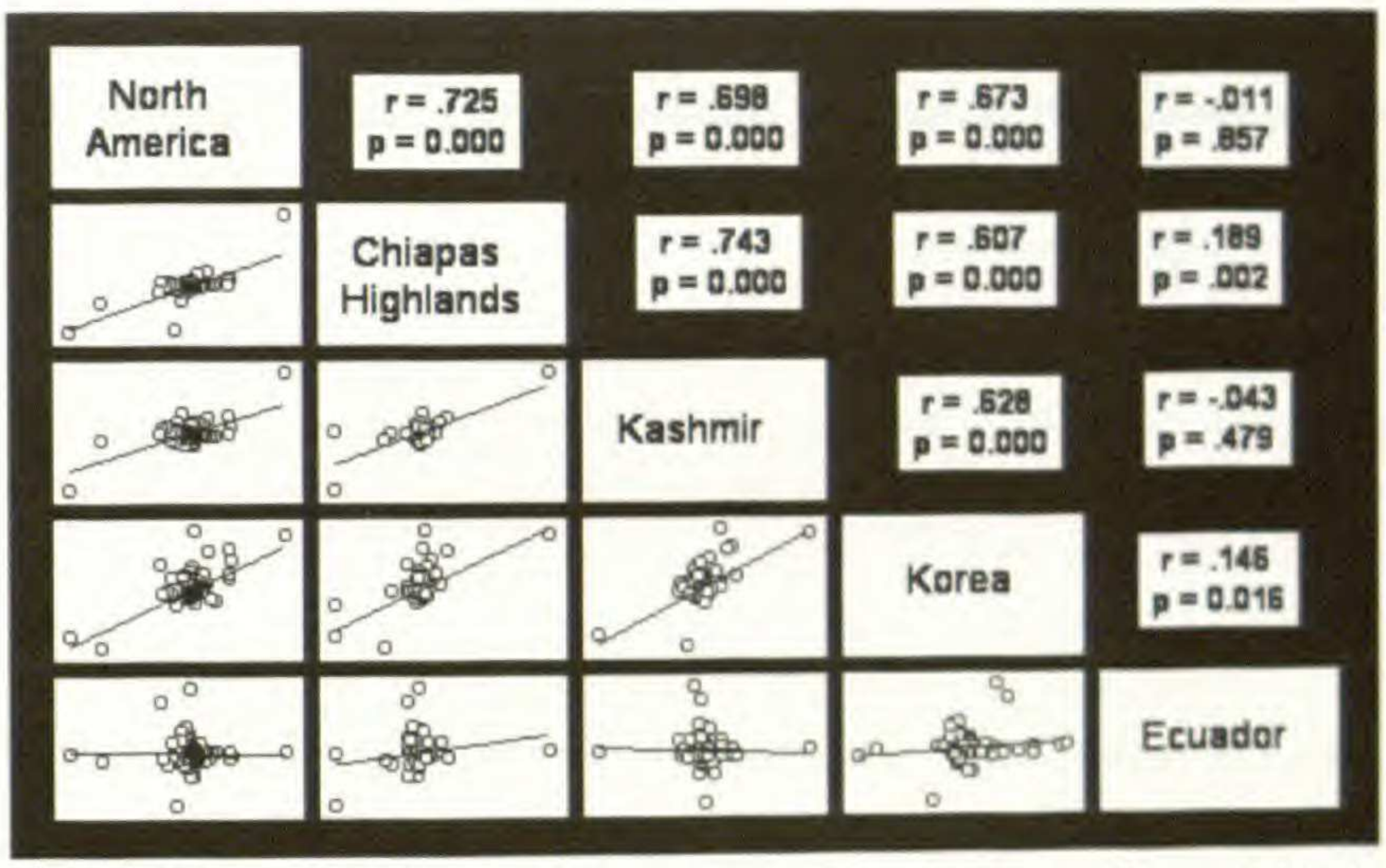


FIGURE 2.– Pearson Product Moment Correlation Coefficients for residuals by family. These graphs represent the correlations between residuals by family for all pairs of the five regions. A Pearson correlation coefficient demonstrates the degree of relationship between two variables (Runyon and Haber 1984). If the two variables are identical, the correlation is 1. If there is no relationship at all, the correlation is zero. Generally, as the correlations are nearer to one, it means that the residual on regression for a particular family in each of two places was alike. In cases where a family exists in one location but not in the other, it is not considered in making the calculation.

TABLE 2.– Ranking by residual for the most selected families in 5 regions. The table lists the 5 most utilized plant families in 5 regions (the top 5 are listed in **bold face**). A dash (Araceae in Chiapas, for example) indicates that the family doesn't exist there. There is a substantial overlap of families in 4 regions. Asteraceae ranks first on the list of families in North America, Kashmir, and Chiapas; it ranks second in Korea. The top 5 families in Ecuador are very different from the other 4 regions; none of the top 5 in Ecuador appear on the list of the top 5 in 4 other regions. The families are listed in the order of the sum of the rankings for the four similar regions (Asteraceae = 5, Lamiaceae = 17, etc.), and by their order in Ecuador.

| FAMILY | North America | Korea | Kashmir | Chiapas Highlands | Ecuador |
|---|---|---|---|---|---|
| Asteraceae | **1** | 2 | 1 | 1 | 47 |
| Lamiaceae | 8 | 3 | 4 | 2 | 95 |
| Apiaceae | 2 | **5** | 11 | **5** | 71 |
| Ranunculaceae | 5 | 4 | 3 | 17 | - |
| Liliaceae | 20 | 1 | 5 | 12 | - |
| Solanaceae | 14 | 24 | 6 | 3 | 16 |
| Rosaceae | 4 | 13 | 37 | 4 | - |
| Ericaceae | 3 | 17 | 60 | 13 | 79 |
| Euphorbiaceae | 234 | 12 | **2** | 21 | 85 |
| Araceae | 39 | 8 | 90 | - | 1 |
| Fabaceae | 253 | 7 | 85 | 131 | 2 |
| Bignoniaceae | 223 | - | 56 | 128 | 3 |
| Loganiaceae | 211 | 110 | 35 | 52 | 4 |
| Malvaceae | 238 | 118 | 13 | 19 | 5 |

to make these comparisons. Generally, we follow Kartesz' terminology for families which occur in North America (Kartesz 1994) and Mabberley for families outside North America (Mabberley 1993).

*North America*.– The North American data have been described and analyzed using similar techniques (Moerman 1996). These data represent the uses of medicinal plants by some 291 different native American groups north of the Rio Grande. These data are fully published elsewhere (Moerman 1998). There are in this region a total of 20,669 species of angiosperms from 255 families of which 2,428 (from 160 families) are used in some way or other as a medicine by at least 1 of some 216 native American groups. The 5 most utilized angiosperm families in a residual analysis are Asteraceae, Apiaceae, Ericaceae, Rosaceae and Ranunculaceae. The 5 least utilized families are Poaceae, Cyperaceae, Fabaceae, Scrophulariaceae and Rubiaceae.

*Kashmir*.– The Indian data represented here have been described before (Kapur et al. 1992). Kashmir, in northeastern India, has a "hilly topography ranging from 300 meters to 2,780 meters above sea level. The region consists of limestone, quartzites, grit and earthy clay," (Kapur et al. 1992: 87) and contains dense forests in an extremely hilly, arduous and rugged terrain.

Collected in a much smaller region than the North American data, there are 739 angiosperm species from 100 families of which 466 species (from 100 families) are used medicinally.[1] The 5 most utilized medicinal families in Kashmir are Asteraceae, Euphorbiaceae, Ranunculaceae, Lamiaceae and Liliaceae. The 5 least utilized families are Poaceae, Urticaceae, Anacardiaceae, Brassicaceae and Cucurbitaceae..

*Korea*.– The Korean data were collected and edited by Robert Pemberton. Those data represent a total of 2,506 species of angiosperms from 136 families of which 591 species (from 97 families) were used medicinally in Korea. The sources for the data are 2 Korean language floras, one a medicinal flora (Lee 1971) and the other a flora of the higher plants of Korea (Lee 1979). Both floras cover the whole Korean Peninsula which encompasses both South and North Korea. The Korean Peninsula is quite mountainous and varies in altitude from sea level to more than 2,700 meters in the mountains along the border between North Korea and China. The Peninsula and associated islands lie between 33$^{\infty}$ and 37$^{\infty}$ N latitude. It has a strongly seasonal climate with hot monsoonal summers and cold, dry winters. The natural vegetation is composed of broad-leaved, evergreen forests along the southern coast and islands; warm temperate, deciduous forests with pine (primarily *Pinus densiflora* Sieb. et Zucc.) in the lowlands and middle elevations; and cool temperate, deciduous-conifer forests in the mountains. Plants used as medicine grow in natural forests, occur as "weeds" in agricultural fields and on other disturbed sites, and some are cultivated.[1] The 5 most heavily utilized families for medicinal purposes according to the regression analysis in Korea are Liliaceae, Asteraceae, Lamiaceae, Ranunculaceae and Apiaceae. The 5 least heavily utilized are Cyperaceae, Poaceae, Orchidaceae, Saxifragaceae and Salicaceae.

*Chiapas Highlands*.– The material from the Chiapas Highlands was collected and arranged by Brent Berlin. Chiapas is a botanically complex mountainous region with elevations ranging from sea level to 4000 meters in the Sierra Madre mountains near the Guatemala border. In the central plateau region where the ethnobotanical data were obtained, summits range from 2100 meters to 2900 meters. The area is generally comprised of tropical deciduous forest and pine-oak forest with moister rain forest cover on the eastern escarpment. The summits and eastern slopes have diverse evergreen cloud forests with many endemic species. The botany and ethnobotany of Chiapas is described by Berlin, Breedlove and Raven (Berlin et al. 1974). The data considered here include 144 angiosperm families[1] with a total of 6617 species of which 1645 species (from 138 families) are used medicinally. The 5 families most heavily utilized for medicines by the regression analysis in Chiapas are Asteraceae, Lamiaceae, Solanaceae, Rosaceae and Apiaceae. The 5 least utilized are Poaceae, Orchidaceae, Cyperaceae, Bromeliaceae and Arecaceae.

*Ecuador*.– The material from Ecuador was collected and arranged by David Kiefer. The material represents the botany and ethnobotany of the Upper Napo River valley of the eastern tropical lowlands of Ecuador, and includes Napo river and the 2 rivers – Río Anzu and Río Jatun Yacu – which unite to form it, as well as several tributaries downstream. The terrain is an ecological transition zone be-

TABLE 3.– Rankings of the families least utilized for medicines in 5 regions. Poaceae is least used in 3 regions, and second least in one. A dash (Salicaceae in Ecuador, for example) indicates that the family does not occur there. One of the bottom 5 in Ecuador (Orchidaceae) appears on the bottom 5 list in 2 other regions, but the remaining 4 do not. The families are listed in the order of the sum of the rankings for the four similar regions (Poaceae = 5, Cyperaceae = 12, etc.), and by their order in Ecuador.

| FAMILY | North America | Korea | Kashmir | Chiapas Highlands | Ecuador |
|---|---|---|---|---|---|
| Poaceae | 1 | 2 | 1 | 1 | 67 |
| Cyperaceae | 2 | 1 | 6 | 3 | 16 |
| Bromeliaceae | 23 | - | - | 4 | 10 |
| Arecaceae | 37 | - | 52 | 5 | 110 |
| Orchidaceae | 10 | **3** | 85 | 2 | **1** |
| Fabaceae | **3** | 130 | 16 | 6 | 117 |
| Urticaceae | 41 | 16 | 2 | 122 | 101 |
| Brassicaceae | 9 | 83 | 4 | 126 | - |
| Scrophulariaceae | 4 | 14 | 86 | 138 | 41 |
| Rubiaceae | 5 | 71 | 91 | 62 | 9 |
| Saxifragaceae | 238 | **4** | 82 | 41 | - |
| Cucurbitaceae | 228 | 56 | **5** | 102 | 66 |
| Salicaceae | 250 | **5** | 25 | 112 | - |
| Anacardiaceae | 237 | 115 | **3** | 116 | 33 |
| Moraceae | 222 | 116 | 92 | 30 | 2 |
| Lauraceae | 192 | 105 | 34 | 7 | 3 |
| Clusiaceae | 231 | 72 | 84 | 22 | 4 |
| Annonaceae | 44 | - | - | 44 | 5 |

tween the Andes Mountains and the Amazon Basin lying about 400 to 500 meters above sea level. This area has only recently been surveyed by botanists, and some portion of the flora remains to be identified. A flora for the region has recently been prepared for the Jatun Sacha Biological Station, a private reserve and research facility located on the south bank of the Upper Napo River, 8 km east of Misahualli and 25 km east of the base of the Andes.[1] Approximately 1900 vascular plant species have been identified in the region (Neill 1995).

The Upper Napo River valley is inhabited by a Quichua-speaking indigenous group numbering about 25,000 (Marles et al. 1988), along with colonists from elsewhere in the country. Their medicinal plant use has been described by several investigators (Iglesias 1985; Kohn 1992; Marles et al. 1988). The data considered here include 118 angiosperm families with a total of 1729 species of which 133 species (from 62 families) are used medicinally.[1] The 5 most utilized families for medicines in this region of Ecuador are Araceae, Fabaceae, Bignoniaceae, Loganiaceae and Malvaceae. The 5 least utilized are Orchidaceae, Moraceae, Lauraceae, Clusiaceae and Cecropiaceae.

## DISCUSSION

Table 2 shows that it requires only 9 families to list the top 5 in 4 of the 5 regions (all but Ecuador). If there were no overlap at all, and the botanical selections were unique in the 5 regions, it would take 20 families to make such a list. If there were total overlap, it would take 5. Asteraceae is first in 3 of the 4 regions, and 2$^{nd}$ in the fourth, and is undoubtedly the most important medicinal plant family by this analysis. In those 4 areas, the one obvious anomaly is the apparent neglect in North America of the Euphorbiaceae (where it is ranked 234); that family ranks second in Kashmir, 12$^{th}$ in Korea and 21$^{st}$ in Chiapas. Otherwise, there is a remarkable overlap of these important families. With only 3 exceptions, families in the top 5 of any of the 4 regions rank in the top quarter of the lists of the other 3 ; most rank within the top tenth of the other 3. The exceptions are the Euphorbiaceae, as already mentioned, and the Rosaceae and Ericaceae, which are both in the middle third of the list in Kashmir. Ecuador, where none of the top 5 appears in the top 5 of any other region, is obviously very different: a substantially different gropu of families provide the largest number of medicinal species.

Table 3 shows that there is less agreement about which families are ignored than about which ones are utilized. Again, setting Ecuador aside, Poaceae is at the bottom of 3 lists and 2$^{nd}$ from the bottom in a fourth. Cyperaceae is also ignored for medicinal use in the 4 regions (and is low even in Ecuador).

Orchidaceae is a curious case. This is perhaps the largest family of plants in the world — one estimate suggests there are 17,500 species worldwide (Mabberley 1993) — yet it generally has few uses other than as an ornamental, as the source for vanilla and salep, and occasionally as a medicine. The distribution of the family is obviously skewed to the tropics; only 322 of those species occur in North America and only 26 of these are used medicinally. Only 2 of the 132 species in Ecuador are used medicinally, where it is listed last on the regression; it is listed near the bottom of the list in 3 other regions, but is relatively high in Kashmir.

Another anomalous family is Fabaceae which is very low in 3 samples (North America, 3rd from the bottom; Chiapas, 6th from the bottom; and Kashmir, 16th from the bottom) but quite high on 2 others (Ecuador, 2nd from the top; Korea; 7th from the top). Both Orchidaceae and Fabaceae might repay close comparative analysis in these different ethnographic and biogeographic contexts.

An alternate statistical test confirms this visual interpretation of regression residuals. Figure 2 shows a series of correlations, and correlation plots, between residuals on the regressions described earlier. In the 4 similar floras, the correlation coefficients range from 0.607 (Chiapas/Korea) to 0.743 (Chiapas/Kashmir). The 4 correlations between the residuals on regression in Ecuador with the other areas are much lower and vary from -0.043 (Ecuador/Kashmir) to 0.189 (Ecuador/Chiapas).

Generally, then, the medicinal floras of 4 areas considered here — North America, Korea, Kashmir and the Highlands of Chiapas — are remarkably similar, particularly in the plant families selected for intensive use, and somewhat less in the families particularly ignored. The situation in Ecuador is, however, distinctly different than in the other 4 areas.

## CONCLUSIONS

How might one account for this extraordinary overlap of plant use in such widely divergent parts of the world? Two factors may be at play, one botanical and the other ethnological. The 4 more similar regions are all part of what Good ( 1974) called the "Boreal Kingdom," and what Takhtajan ( 1986) calls the "Holarctic Kingdom" while Ecuador is part of what both call the "Neotropical Kingdom." It may be worth noting that although Chiapas seems to be far enough south that it might have a tropical flora, it does not. Good, for example, quite explicitly includes Chiapas at the southern end of the "Pacific North America" floristic region of the Boreal Kingdom.

Insofar as the 4 northern floras are related at the family and genus levels, then there will likely be a common chemistry that would encourage the selection of related species in different floras for medicine. This factor would be enhanced by taking a long view on the relatedness of peoples and knowledge in Asia and North America, and recognizing that knowledge of medicinal species may have been transmitted via migrating peoples throughout Asia, from Asia to North America, and south to Chiapas. Koreans are thought to have migrated from Mongolia which shares floristic characteristics with Tibet and with Kashmir. Northern Asians migrated to North America and then southward. It seems likely that as related peoples moved through related floras, they were able to select similar species (in different parts of Asia and in far northern areas of Asia and North America, since the floras are very similar in the far north), and then select different but obviously related species as they moved south to Korea or to more southern areas of North America and to Chiapas. By the time people reached the tropical regions of Ecuador, where the floristics were dramatically different than they were further north, people had to develop a new range of ethnobotanical knowledge.

The genus *Achillea* ("yarrow") serves as a good example (Figure 3). *Achillea*

FIGURE 3.– *Achillea millefolium*, L., Asteraceae, yarrow. By Marie Cole. From Daniel E. Moerman, *Geraniums for the Iroquois.* (Reference Publications, Algonac MI. 1982). Used by permission.

*millefolium* L., a member of the Asteraceae family, has more medicinal uses (359) in a standard listing of native North American plant use (Moerman 1998) than any other single species. *Achillea* is also found, and used medicinally, in Kashmir, Korea and Chiapas. It was probably known in ancient times as it was the most common of the pollens found in the famous 60,000 year old Neanderthal burial of Shanidar IV in northern Iraq (Leroi-Gourhan 1975). It was named after Achilles who is said by classical authors (Apollodorus, Homer, Pliny) to have discovered its virtues for healing wounds (Graves 1960:285). The genus is not reported in Amazonian Ecuador (Renner et al. 1990). Yarrows are perennial forbs with distinctive flowers, scent and foliage which contain a broad range of chemicals which have been of interest to scientists throughout the 20th century (Miller 1916); a recent compilation lists over 150 compounds (Buckingham 1994(7):377-79) including 3 forms of achimillic acid which have recently been shown to be active against leukemia (Tozyo et al. 1994). Knowledge of the utility of this plant is broad and deep, as it is for other closely related members of the Asteraceae occuring in Asia and North America, and as far south as Chiapas (e.g., *Artemisia*, *Aster*, and *Lactuca*).

The similarity of medicinal plant use we have found suggests that human knowledge is deeply rooted. While it seems unlikely that there is a continuous skein of knowledge of individual species back to the Middle Paleolithic, these data suggest that non-Western peoples speaking unrelated languages have somehow generated similarly useful knowledge over broad geographic regions, or carried the knowledge of drug plants with them throughout Asia and to America in their migrations since the Upper Paleolithic, or both. Recognizing such patterns could increase the efficiency of contemporary prospecting for useful phytochemicals at the same time as they demonstrate the existence of a global pattern of human knowledge.

## NOTES

2. The equation for the line is a constant (.284) plus a coefficient (.114) multiplied times the number of species in the family. The constant indicates where the graph line intercepts the vertical axis, and the coefficient represents the slope of the graph line:

$$MSp = .284 + (.114 * TSp)$$

This equation represents what the distribution of points would be if everything were distributed randomly, and gives us what is called the "predicted values" of the analysis. For example, there are 2,688 species of Asteraceae in North America. If plant selection were random, one would predict that the number of species of Asteraceae used medicinally would be .284 + (.114 * 2688) = 306.7. However, native American peoples used 397 species of Asteraceae medicinally, many more than the regression analysis predicts. The "residual" is the actual value minus the predicted value, 397 - 306.7 = 90.3. On the graph, the residual is represented by the vertical distance from the regression line to the data point, shown by the upward pointing arrow. The regression analysis predicts that native Americans would use 171.8 species of Poaceae medicinally; however, they used only 62. The residual, -109.8, is represented on the graph by the downward pointing arrow.

Why use this method? One might simply rank the families in terms of the number of medicinal species native peoples used. If we did this, the top 3 medicinal families would be Asteraceae, Fabaceae and Rosaceae. But these are all large families which we might expect to produce many medicinal species. That suggests that we might want to rank the families not by the number of medicinal species, but by the proportion or percentage of them. However, there are a number of very small families of plants in north America in which all of their species (e.g., 100% of them) are used medicinally. Among these are Butomaceae (1 of 1), Datiscaceae (1 of 1) and Saururaceae (2 of 2). Ranked this way, the families which appeared at the top of a list by simple enumeration, are lost in the middle of the list: Asteraceae is in 81$^{st}$ place, Fabaceae is in 111$^{th}$, and Rosaceae is 73$^{rd}$. The regression-residual system has the advantage of not overemphasizing small families, and, most valuable, it differentiates among large families which produce relatively larger and relatively smaller numbers of medicinal species (like Asteraceae and Poaceae).

Note that this method is not meant to suggest that a particular medicinal species, or family, (like Datisca glomerata (K. Presl) Baill. Durango-Root, Datiscaceae) is not "important." But it is meant to allow analysis of the uses of large numbers of plants using some technique other than simply considering them one at a time.

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APPENDIX 1.– Number of medicinal species per family, and total species per family, for angiosperms in 5 regions.

| | North America | | Korea | | Chiapas Highlands | | Kashmir | | Ecuador | |
|---|---|---|---|---|---|---|---|---|---|---|
| FAMILY | Med | Total | Med | Total | Med | Total | Med | Total | Med | Total |
| Acanthaceae | 2 | 111 | 1 | 3 | 21 | 93 | 11 | 17 | 2 | 31 |
| Aceraceae | 10 | 19 | 4 | 12 | 1 | 1 | 2 | 2 | 0 | 0 |
| Achatocarpaceae | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Acoraceae | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Actinidiaceae | 0 | 0 | 4 | 4 | 4 | 15 | 0 | 0 | 1 | 2 |
| Adoxaceae | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Agavaceae | 11 | 94 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Aizoaceae | 0 | 22 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 1 |
| Alangiaceae | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Alismataceae | 5 | 37 | 2 | 5 | 0 | 0 | 0 | 0 | 0 | 1 |
| Aloaceae | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Amaranthaceae | 4 | 112 | 3 | 9 | 12 | 38 | 11 | 13 | 0 | 4 |
| Anacardiaceae | 11 | 35 | 5 | 6 | 7 | 17 | 2 | 9 | 0 | 4 |
| Annonaceae | 1 | 22 | 0 | 0 | 5 | 24 | 0 | 0 | 0 | 22 |
| Apiaceae | 85 | 397 | 23 | 59 | 25 | 48 | 12 | 18 | 0 | 1 |
| Apocynaceae | 7 | 62 | 2 | 5 | 11 | 45 | 4 | 7 | 2 | 16 |
| Aponogetonaceae | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Aquifoliaceae | 6 | 29 | 1 | 5 | 2 | 12 | 2 | 2 | 1 | 1 |
| Araceae | 8 | 46 | 12 | 14 | 0 | 0 | 2 | 5 | 11 | 77 |
| Araliaceae | 9 | 36 | 14 | 15 | 15 | 18 | 1 | 1 | 0 | 6 |
| Arecaceae | 3 | 45 | 0 | 0 | 1 | 47 | 1 | 1 | 3 | 21 |
| Aristolochiaceae | 7 | 38 | 3 | 4 | 0 | 15 | 0 | 0 | 0 | 3 |
| Asclepiadaceae | 26 | 149 | 8 | 13 | 18 | 78 | 5 | 7 | 0 | 4 |
| Asteraceae | 397 | 2688 | 55 | 226 | 264 | 602 | 54 | 64 | 2 | 27 |
| Balanophoraceae | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Balsaminaceae | 2 | 11 | 1 | 2 | 1 | 4 | 2 | 2 | 0 | 0 |
| Basellaceae | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Bataceae | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Begoniaceae | 0 | 10 | 0 | 0 | 7 | 39 | 1 | 1 | 0 | 3 |
| Berberidaceae | 17 | 33 | 6 | 7 | 1 | 5 | 2 | 3 | 0 | 0 |
| Betulaceae | 19 | 31 | 5 | 22 | 4 | 4 | 0 | 0 | 0 | 0 |
| Bignoniaceae | 1 | 32 | 0 | 0 | 7 | 56 | 1 | 1 | 4 | 20 |
| Bixaceae | 0 | 5 | 0 | 0 | 2 | 4 | 0 | 0 | 1 | 2 |
| Bombacaceae | 0 | 5 | 0 | 0 | 1 | 9 | 1 | 1 | 1 | 15 |
| Boraginaceae | 30 | 392 | 2 | 21 | 21 | 51 | 5 | 12 | 2 | 13 |
| Brassicaceae | 67 | 685 | 9 | 51 | 11 | 28 | 6 | 16 | 0 | 0 |
| Bromeliaceae | 1 | 43 | 0 | 0 | 3 | 115 | 0 | 0 | 0 | 17 |

| | North America | | Korea | | Chiapas Highlands | | Kashmir | | Ecuador | |
|---|---|---|---|---|---|---|---|---|---|---|
| FAMILY | Med | Total | Med | Total | Med | Total | Med | Total | Med | Total |
| Brunelliaceae | 0 | 1 | 0 | 0 | 0 | 9 | 0 | 0 | 0 | 0 |
| Burmanniaceae | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Burseraceae | 1 | 6 | 0 | 0 | 2 | 14 | 0 | 0 | 0 | 16 |
| Butomaceae | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Buxaceae | 0 | 6 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| Cabombaceae | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cactaceae | 20 | 199 | 0 | 0 | 1 | 40 | 1 | 1 | 1 | 4 |
| Callitrichaceae | 0 | 12 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Calycanthaceae | 2 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Calyceraceae | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Campanulaceae | 12 | 228 | 10 | 26 | 8 | 26 | 1 | 1 | 0 | 5 |
| Canellaceae | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cannabaceae | 2 | 3 | 2 | 2 | 0 | 0 | 1 | 1 | 0 | 0 |
| Cannaceae | 0 | 8 | 0 | 0 | 1 | 5 | 0 | 0 | 0 | 0 |
| Capparaceae | 2 | 45 | 0 | 0 | 2 | 28 | 0 | 0 | 1 | 5 |
| Caprifoliaceae | 30 | 80 | 4 | 41 | 9 | 14 | 4 | 8 | 0 | 0 |
| Caricaceae | 1 | 1 | 0 | 0 | 1 | 5 | 0 | 0 | 0 | 1 |
| Caryocaraceae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| Caryophyllaceae | 23 | 336 | 8 | 56 | 11 | 29 | 5 | 7 | 0 | 1 |
| Casuarinaceae | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cecropiaceae | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 22 |
| Celastraceae | 7 | 40 | 3 | 16 | 7 | 47 | 1 | 2 | 1 | 13 |
| Ceratophyllaceae | 0 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cercidiphyllaceae | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Chenopodiaceae | 23 | 188 | 2 | 16 | 5 | 5 | 2 | 3 | 0 | 0 |
| Chloranthaceae | 0 | 1 | 0 | 3 | 1 | 1 | 0 | 0 | 0 | 0 |
| Chrysobalanaceae | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 |
| Cistaceae | 3 | 37 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 |
| Clethraceae | 1 | 2 | 0 | 1 | 5 | 10 | 0 | 0 | 0 | 0 |
| Clusiaceae | 13 | 70 | 2 | 8 | 5 | 29 | 3 | 3 | 0 | 25 |
| Combretaceae | 0 | 8 | 0 | 0 | 2 | 14 | 1 | 3 | 0 | 6 |
| Commelinaceae | 6 | 56 | 1 | 5 | 15 | 47 | 1 | 1 | 2 | 9 |
| Connaraceae | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Convolvulaceae | 12 | 141 | 5 | 13 | 23 | 97 | 6 | 12 | 0 | 5 |
| Coriariaceae | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| Cornaceae | 11 | 20 | 2 | 9 | 3 | 3 | 1 | 1 | 0 | 0 |
| Corynocarpaceae | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Costaceae | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crassulaceae | 10 | 113 | 5 | 25 | 4 | 25 | 2 | 2 | 1 | 1 |
| Crossosomataceae | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cucurbitaceae | 13 | 73 | 1 | 6 | 14 | 53 | 2 | 8 | 1 | 18 |
| Cunoniaceae | 0 | 1 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 |
| Cuscutaceae | 4 | 52 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| Cyatheaceae | 1 | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cycadaceae | 0 | 2 | 0 | 0 | 0 | 7 | 0 | 0 | 0 | 0 |
| Cyclanthaceae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 17 |
| Cymodoceaceae | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Cyperaceae | 25 | 918 | 5 | 210 | 13 | 184 | 4 | 11 | 1 | 27 |

| | North America | | Korea | | Chiapas Highlands | | Kashmir | | Ecuador | |
|---|---|---|---|---|---|---|---|---|---|---|
| FAMILY | Med | Total | Med | Total | Med | Total | Med | Total | Med | Total |
| Cyrillaceae | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Datiscaceae | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Davalliaceae | 0 | 11 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Diapensiaceae | 1 | 5 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Dichapetalaceae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 |
| Dilleniaceae | 0 | 2 | 0 | 0 | 1 | 6 | 0 | 0 | 0 | 9 |
| Dioscoreaceae | 1 | 15 | 5 | 7 | 7 | 19 | 2 | 2 | 0 | 0 |
| Dipsacaceae | 1 | 13 | 0 | 2 | 0 | 0 | 1 | 2 | 0 | 0 |
| Droseraceae | 2 | 8 | 0 | 3 | 0 | 0 | 1 | 1 | 0 | 0 |
| Ebenaceae | 1 | 7 | 2 | 2 | 1 | 7 | 0 | 0 | 0 | 3 |
| Elaeagnaceae | 4 | 10 | 1 | 6 | 0 | 0 | 1 | 2 | 0 | 0 |
| Elaeocarpaceae | 0 | 3 | 0 | 0 | 1 | 9 | 0 | 0 | 2 | 5 |
| Elatinaceae | 0 | 11 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Eleocarpaceae | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Empetraceae | 1 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Epacridaceae | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Eremolepidaceae | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ericaceae | 63 | 213 | 11 | 33 | 18 | 44 | 1 | 1 | 0 | 3 |
| Eriocaulaceae | 0 | 16 | 2 | 9 | 0 | 0 | 0 | 0 | 0 | 1 |
| Erythroxylaceae | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 |
| Euphorbiaceae | 38 | 368 | 10 | 20 | 52 | 204 | 17 | 19 | 3 | 60 |
| Fabaceae | 152 | 1557 | 24 | 85 | 147 | 676 | 37 | 69 | 12 | 121 |
| Fagaceae | 28 | 94 | 7 | 16 | 9 | 27 | 1 | 2 | 0 | 0 |
| Flacourtiaceae | 0 | 22 | 0 | 2 | 7 | 27 | 2 | 3 | 1 | 26 |
| Fouquieriaceae | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Frankeniaceae | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Garryaceae | 2 | 8 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 |
| Gentianaceae | 17 | 117 | 7 | 23 | 11 | 25 | 1 | 4 | 0 | 3 |
| Geraniaceae | 9 | 64 | 8 | 14 | 4 | 13 | 4 | 5 | 0 | 0 |
| Gesneriaceae | 0 | 64 | 0 | 0 | 7 | 62 | 0 | 0 | 3 | 27 |
| Goetzeaceae | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Goodeniaceae | 1 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Grossulariaceae | 19 | 56 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gunneraceae | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gyrocarpaceae | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 |
| Haemodoraceae | 1 | 3 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 |
| Haloragaceae | 3 | 19 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hamamelidaceae | 2 | 5 | 0 | 2 | 1 | 2 | 0 | 0 | 0 | 0 |
| Heliconiaceae | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hernandiaceae | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| Hippocastanaceae | 4 | 7 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 |
| Hippuridaceae | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hydrangeaceae | 5 | 51 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 0 |
| Hydrocharitaceae | 1 | 19 | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 |
| Hydrophyllaceae | 18 | 234 | 0 | 0 | 4 | 7 | 0 | 0 | 0 | 0 |
| Icacinaceae | 0 | 2 | 0 | 0 | 1 | 6 | 0 | 0 | 1 | 6 |
| Illiciaceae | 0 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Iridaceae | 17 | 111 | 4 | 10 | 18 | 24 | 1 | 1 | 0 | 0 |

| | North America | | Korea | | Chiapas Highlands | | Kashmir | | Ecuador | |
|---|---|---|---|---|---|---|---|---|---|---|
| FAMILY | Med | Total | Med | Total | Med | Total | Med | Total | Med | Total |
| Joinvilleaceae | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Juglandaceae | 9 | 23 | 2 | 2 | 1 | 5 | 0 | 0 | 0 | 0 |
| Juncaceae | 6 | 135 | 1 | 23 | 1 | 15 | 0 | 0 | 0 | 0 |
| Juncaginaceae | 1 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Krameriaceae | 2 | 5 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 |
| Lacistemataceae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| Lamiaceae | 72 | 469 | 27 | 60 | 59 | 129 | 25 | 37 | 0 | 5 |
| Lardizabalaceae | 0 | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lauraceae | 6 | 40 | 5 | 12 | 10 | 82 | 2 | 3 | 0 | 39 |
| Lecythidaceae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 9 |
| Leeaceae | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| Leitneriaceae | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lemnaceae | 1 | 19 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lennoaceae | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lentibulariaceae | 2 | 29 | 0 | 7 | 3 | 14 | 0 | 0 | 0 | 0 |
| Liliaceae | 65 | 509 | 40 | 98 | 26 | 78 | 9 | 9 | 1 | 4 |
| Limnanthaceae | 0 | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Limnocharitaceae | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Linaceae | 5 | 50 | 0 | 1 | 5 | 5 | 1 | 2 | 0 | 0 |
| Loasaceae | 6 | 76 | 0 | 0 | 1 | 7 | 0 | 0 | 0 | 0 |
| Loganiaceae | 3 | 39 | 0 | 3 | 7 | 25 | 2 | 2 | 3 | 6 |
| Lophosoriaceae | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Loranthaceae | 0 | 4 | 1 | 4 | 10 | 47 | 1 | 2 | 1 | 12 |
| Lythraceae | 3 | 38 | 2 | 7 | 20 | 54 | 2 | 2 | 0 | 4 |
| Magnoliaceae | 5 | 11 | 4 | 5 | 0 | 0 | 0 | 0 | 0 | 1 |
| Malpighiaceae | 0 | 33 | 0 | 0 | 17 | 54 | 0 | 0 | 2 | 11 |
| Malvaceae | 23 | 263 | 0 | 4 | 32 | 116 | 7 | 9 | 3 | 8 |
| Marantaceae | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 20 |
| Marattiaceae | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Marcgraviaceae | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Mayacaceae | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Melastomataceae | 1 | 71 | 0 | 0 | 18 | 108 | 0 | 0 | 4 | 71 |
| Meliaceae | 1 | 10 | 0 | 0 | 7 | 20 | 3 | 3 | 1 | 27 |
| Menispermaceae | 2 | 8 | 4 | 4 | 0 | 0 | 3 | 3 | 2 | 21 |
| Menyanthaceae | 2 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Molluginaceae | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Monimiaceae | 0 | 0 | 0 | 0 | 2 | 4 | 0 | 0 | 2 | 13 |
| Moraceae | 7 | 30 | 6 | 11 | 12 | 57 | 7 | 7 | 1 | 60 |
| Morinaceae | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| Moringaceae | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Musaceae | 0 | 3 | 0 | 0 | 1 | 11 | 0 | 0 | 1 | 10 |
| Myoporaceae | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Myricaceae | 3 | 10 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| Myristicaceae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 22 |
| Myrsinaceae | 0 | 34 | 2 | 3 | 25 | 82 | 2 | 3 | 1 | 5 |
| Myrtaceae | 3 | 120 | 0 | 0 | 16 | 81 | 0 | 0 | 0 | 11 |
| Najadaceae | 0 | 8 | 0 | 3 | 1 | 1 | 0 | 0 | 0 | 0 |
| Nelumbonaceae | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | North America | | Korea | | Chiapas Highlands | | Kashmir | | Ecuador | |
|---|---|---|---|---|---|---|---|---|---|---|
| FAMILY | Med | Total | Med | Total | Med | Total | Med | Total | Med | Total |
| Nyctaginaceae | 17 | 124 | 0 | 0 | 9 | 26 | 2 | 2 | 0 | 3 |
| Nymphaeaceae | 2 | 14 | 4 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ochnaceae | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 4 |
| Olacaceae | 1 | 5 | 0 | 0 | 3 | 12 | 0 | 0 | 2 | 6 |
| Oleaceae | 9 | 66 | 6 | 24 | 4 | 17 | 5 | 9 | 0 | 1 |
| Onagraceae | 29 | 276 | 10 | 17 | 16 | 31 | 2 | 2 | 1 | 4 |
| Orchidaceae | 26 | 322 | 6 | 82 | 25 | 444 | 3 | 3 | 2 | 132 |
| Orobanchaceae | 6 | 24 | 1 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Oxalidaceae | 5 | 30 | 3 | 3 | 5 | 16 | 3 | 5 | 0 | 1 |
| Paeoniaceae | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pandanaceae | 2 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Papaveraceae | 13 | 97 | 9 | 17 | 3 | 9 | 2 | 4 | 0 | 0 |
| Passifloraceae | 1 | 35 | 0 | 0 | 8 | 40 | 0 | 0 | 0 | 9 |
| Pedaliaceae | 3 | 10 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| Phytolaccaceae | 1 | 14 | 2 | 3 | 6 | 9 | 0 | 0 | 2 | 6 |
| Piperaceae | 2 | 64 | 0 | 1 | 21 | 94 | 0 | 0 | 3 | 39 |
| Pittosporaceae | 0 | 15 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Plantaginaceae | 9 | 35 | 4 | 5 | 3 | 4 | 2 | 3 | 0 | 0 |
| Platanaceae | 2 | 4 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| Plumbaginaceae | 4 | 13 | 0 | 1 | 1 | 3 | 1 | 1 | 0 | 0 |
| Poaceae | 62 | 1505 | 5 | 178 | 28 | 460 | 24 | 79 | 2 | 34 |
| Podocarpaceae | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Podostemaceae | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Polemoniaceae | 37 | 284 | 0 | 1 | 3 | 11 | 0 | 0 | 0 | 0 |
| Polygalaceae | 8 | 64 | 1 | 4 | 10 | 33 | 2 | 3 | 0 | 1 |
| Polygonaceae | 65 | 433 | 18 | 66 | 13 | 45 | 12 | 16 | 0 | 8 |
| Pontederiaceae | 2 | 13 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 2 |
| Portulacaceae | 7 | 105 | 1 | 1 | 0 | 6 | 1 | 1 | 0 | 0 |
| Posidoniaceae | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Potamogetonaceae | 1 | 42 | 1 | 14 | 0 | 0 | 0 | 0 | 0 | 0 |
| Primulaceae | 9 | 97 | 2 | 26 | 1 | 9 | 4 | 7 | 0 | 0 |
| Proteaceae | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Punicaceae | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| Quiinaceae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| Rafflesiaceae | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ranunculaceae | 74 | 319 | 33 | 104 | 10 | 18 | 18 | 22 | 0 | 0 |
| Resedaceae | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rhamnaceae | 18 | 110 | 2 | 14 | 14 | 21 | 6 | 7 | 0 | 6 |
| Rhizophoraceae | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Rosaceae | 133 | 836 | 26 | 126 | 34 | 71 | 13 | 23 | 0 | 0 |
| Rubiaceae | 17 | 318 | 6 | 34 | 54 | 232 | 11 | 16 | 6 | 130 |
| Rutaceae | 8 | 103 | 9 | 11 | 10 | 41 | 4 | 6 | 1 | 6 |
| Sabiaceae | 0 | 2 | 0 | 2 | 1 | 4 | 0 | 0 | 0 | 5 |
| Salicaceae | 37 | 112 | 2 | 37 | 4 | 6 | 1 | 2 | 0 | 0 |
| Santalaceae | 3 | 14 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sapindaceae | 2 | 34 | 1 | 2 | 16 | 60 | 1 | 4 | 2 | 23 |
| Sapotaceae | 2 | 30 | 0 | 0 | 0 | 29 | 0 | 0 | 1 | 38 |
| Sarraceniaceae | 1 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

| | North America | | Korea | | Chiapas Highlands | | Kashmir | | Ecuador | |
|---|---|---|---|---|---|---|---|---|---|---|
| FAMILY | Med | Total | Med | Total | Med | Total | Med | Total | Med | Total |
| Saururaceae | 2 | 2 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| Saxifragaceae | 27 | 175 | 3 | 53 | 1 | 7 | 3 | 3 | 0 | 0 |
| Scheuchzeriaceae | 0 | 1 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Schisandraceae | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Scrophulariaceae | 72 | 832 | 9 | 65 | 28 | 85 | 12 | 19 | 0 | 3 |
| Simaroubaceae | 1 | 11 | 0 | 0 | 2 | 12 | 0 | 0 | 0 | 4 |
| Simmondsiaceae | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Smilacaceae | 8 | 22 | 0 | 0 | 5 | 18 | 1 | 1 | 0 | 0 |
| Solanaceae | 34 | 202 | 5 | 9 | 60 | 164 | 10 | 11 | 4 | 47 |
| Sparganiaceae | 1 | 9 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sphenocleaceae | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Staphyleaceae | 1 | 3 | 0 | 2 | 1 | 5 | 0 | 0 | 0 | 2 |
| Stemonaceae | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sterculiaceae | 2 | 28 | 0 | 3 | 7 | 37 | 0 | 0 | 3 | 13 |
| Strelitziaceae | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Styracaceae | 0 | 10 | 0 | 3 | 2 | 7 | 0 | 0 | 0 | 0 |
| Surianaceae | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Symplocaceae | 1 | 4 | 0 | 4 | 1 | 8 | 0 | 0 | 0 | 1 |
| Taccaceae | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tamaricaceae | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Taxodiaceae | 1 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Theaceae | 1 | 13 | 1 | 6 | 4 | 9 | 0 | 0 | 0 | 0 |
| Theophrastaceae | 0 | 7 | 0 | 0 | 1 | 4 | 0 | 0 | 1 | 3 |
| Thymelaeaceae | 2 | 21 | 2 | 7 | 3 | 10 | 2 | 4 | 0 | 1 |
| Tiliaceae | 1 | 17 | 0 | 11 | 8 | 44 | 3 | 6 | 1 | 4 |
| Trapaceae | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Triuridaceae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Tropaeolaceae | 0 | 1 | 0 | 0 | 1 | 3 | 0 | 0 | 0 | 0 |
| Turneraceae | 0 | 8 | 0 | 0 | 1 | 7 | 0 | 0 | 0 | 0 |
| Typhaceae | 2 | 3 | 2 | 2 | 1 | 3 | 0 | 0 | 0 | 0 |
| Ulmaceae | 5 | 23 | 4 | 17 | 0 | 0 | 1 | 3 | 0 | 6 |
| Urticaceae | 5 | 60 | 3 | 24 | 16 | 52 | 1 | 8 | 2 | 12 |
| Valerianaceae | 6 | 35 | 3 | 7 | 8 | 13 | 2 | 3 | 0 | 0 |
| Verbenaceae | 17 | 136 | 5 | 10 | 25 | 76 | 5 | 11 | 2 | 16 |
| Violaceae | 13 | 90 | 4 | 42 | 5 | 26 | 2 | 2 | 1 | 8 |
| Viscaceae | 9 | 45 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Vitaceae | 10 | 40 | 2 | 7 | 5 | 16 | 0 | 0 | 1 | 7 |
| Vochysiaceae | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| Winteraceae | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| Xyridaceae | 2 | 24 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Zannichelliaceae | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Zingiberaceae | 2 | 15 | 0 | 0 | 0 | 15 | 3 | 3 | 3 | 12 |
| Zosteraceae | 1 | 5 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| Zygophyllaceae | 4 | 19 | 1 | 1 | 1 | 5 | 1 | 1 | 0 | 0 |
| Total | 2428 | 20669 | 591 | 2506 | 1639 | 6606 | 466 | 739 | 133 | 1729 |

1. In order to reconcile variation in the naming of upper level taxa, some modifications have been made in some of the published work on which this paper is based. These differences are itemized here.

Kashmir. A number of families reported earlier have been combined (Mimosaceae, Caesalpiniaceae and Papilionaceae have been combined as Fabaceae; in the following 4 pairs, the former has been combined with the latter: Ehretiaceae, Boraginaceae; Fumariaceae, Papaveraceae; Parnassiaceae, Saxifragaceae; Podophyllaceae, Berberidaceae; and in the following 3 pairs, the former has been renamed the latter: Hypericaceae, Clusiaceae; Martyniaceae, Pedaliaceae; Philadelphaceae, Hydrangeaceae). In this account, then, there are 100, not 106 families as in the original publication. Two Kashmir families are not represented in any of the other data sets: Leeaceae and Morinaceae.

Korea. For the following pairs of families, the former was included in the latter: Fumariaceae, Papaveraceae; Hypericaceae, Clusiaceae; Lobeliaceae, Campanulaceae; Nepenthaceae, Lamiaceae; Pyrolaceae, Ericaceae; Amaryllidaceae, Liliaceae. Several other minor spelling changes were made, like Brassicaceae rather than Brassiacaceae. Only 2 small families found in Korea are not found in any of the other samples considered here, Alangiaceae and Eleocarpaceae.

Chiapas Highlands. Only minor changes in the published family data had to be made to match the remaining data: Cruciferae is treated here as Brassicaceae, for example.

Ecuador. Amaryllidaceae has been folded into Liliaceae, and Hippocrataceae has been included in Celastraceae. Four families have had minor changes in the spellings of their names. Nine families found in Ecuador are not present in any of the other 4 areas indicating something of the uniqueness of the flora.